HIGH PRESSURE ACTUATED METAL SEATED DIAPHRAGM VALVE

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Inventor:	WU JING-CHAU (US); BARBER PATRICK P (US); ALDRIDGE LEWIS L (US)
Applicant:	PARKER HANNIFIN CORP (US)
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An all metal diaphragm valve is provided. The valve includes a housing having an inlet passage and an outlet passage each of which communicates with a valve chamber. Portions of the inlet passage in the valve chamber are surrounded by a toroidal sealing bead. The valve further includes a resilient metallic diaphragm which is dished and in an unbiased condition projects away from the toroidal sealing bead. Thus, fluid may flow through the inlet passage, through the valve chamber and out of the outlet passage. Actuation of a valve stem will cause the metal diaphragm to deflect toward and into sealing engagement with the toroidal sealing bead. The surface of the diaphragm that engages the toroidal sealing bead is formed from a very hard metallic alloy. However adjacent layers of the diaphragm are formed from softer metals.

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(54) HIGH PRESSURE ACTUATED METAL SEATED DIAPHRAGM VALVE

HOCHDRUCKBETÄTIGTES MEMBRANVENTIL MIT METALLISCHER SITZDICHTUNG

VANNE A DIAPHRAGME A SIEGE METALLIQUE, ACTIONNEE PAR UNE FORTE PRESSION

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(73) Proprietor: Parker Hannifin Corporation
Cleveland, OH 44124-4141 (US)

(72) Inventors:
- WU, Jing-Chau
  Morris Plains, NJ 07950 (US)
- BARBER, Patrick, P.
  Kinnelon, NJ 07405 (US)
- ALDRIDGE, Lewis, L.
  Morris Plains, NJ 07950 (US)

(74) Representative:
Müller-Boré & Partner Patentanwälte
Grafinger Strasse 2
81671 München (DE)

(56) References cited:

EP-A- 0 512 674	US-A- 4 828 219
US-A- 5 108 069	US-A- 5 413 311

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Description

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field. The subject invention relates to a diaphragm valve formed substantially from metallic materials to ensure purity of gas flowing therethrough.

[0002] 2. Background Art. The prior art diaphragm valve includes a valve housing formed with a valve chamber. Inlet and outlet passages extend through the valve housing and communicate with the valve chamber. A flexible diaphragm defines one wall of the prior art valve chamber, and is positioned opposite the entry of the inlet passage into the valve chamber.

[0003] The prior art diaphragm valve further includes a diaphragm actuator that communicates with the side of the diaphragm external of the valve chamber. The actuator may comprise a piston, a spring, pressurized fluid or some combination thereof. Forces exerted by the actuator cause the diaphragm to deflect into sealing engagement with portions of the valve housing surrounding the inlet passage to the valve chamber. Movement of the piston away from the valve chamber may move the diaphragm away from the inlet passage and may permit fluid to flow from the inlet passage, through the valve chamber and into the outlet passage. Some prior art diaphragm valves include a diaphragm that is biased into the opened position. Thus movement of the actuator away from the valve chamber may permit the inherent biasing of the diaphragm to open the inlet passages to the valve chamber.

[0004] Prior art diaphragm valves for gas flow systems typically include a valve stem that is movable to deflect the diaphragm and to thereby open or close the valve. Some such prior art valves are manually operable, and include a threaded valve stem engaged in a bonnet on the valve. Manual rotation of the threaded valve stem moves the valve stem axially in the bonnet for deflecting the diaphragm and for opening or closing the valve. Some prior art manually operated diaphragm valves include a short cylindrical member between the threaded valve stem and the diaphragm. The short cylindrical member isolates the diaphragm from the rotational movement of the valve stem, thereby reduces wear on the diaphragm. However, the short cylindrical member adds to the cost of the valve and complicates the assembly. Accordingly there is no apparent reason for including such a short cylindrical member in a situation where rubbing of the valve stem against the diaphragm is not a problem.

[0005] Some prior art diaphragm valves include automatic actuators. The automatic actuators drive the valve stem axially without rotation. Hence, the valve stem of the prior art automatically actuated diaphragm valve will not rub on the diaphragm. Consequently, the short cylindrical member that is used in some prior art manual diaphragm valves has not been provided between the diaphragm and the prior art automatically actuated and axially driven valve stem.

[0006] Effective sealing is an important requirement for virtually all valves. Sealing typically is enhanced by utilizing an elastomeric or plastic material. on one or both members defining a sealing interface. For example, some prior art diaphragm valves include an elastomeric diaphragm that can be urged into sealing engagement with a valve seat surrounding the entry of the inlet passage into the valve chamber. Other diaphragm valves may include an elastomeric or plastic valve seat surrounding the inlet passage and configured for engagement by the diaphragm. Elastomeric or plastic sealing members perform very well in many fluid flow valves, such as valves carrying water and valves carrying liquid chemicals that will react with metals.

[0007] Many industrial processes, such as processes performed in the semi-conductor and microprocessor industries, require the presence of high purity gas. The gases typically are produced at off-site locations, and are delivered to the appropriate manufacturing facility in pressurized containers. The containers then are placed into communication with piping systems for use as needed in the manufacturing facilities. Valves in the piping systems are used to periodically stop, start or control the flow of high purity gas.

[0008] Piping systems for carrying high purity gases at a manufacturing facility should be constructed to maintain the high purity of the gas delivered to the facility. In particular, all parts of the gas delivery system should be constructed from materials that prevent gas diffusion, moisture absorption and dimensional changes in response to certain gas exposure. Gas diffusion and moisture absorption are associated with many plastic and rubber materials. Additionally, certain plastics are known to swell upon exposure to certain gases. Still further, many plastics will degrade rapidly when exposed to high temperature gas flows. As a result, plastic or rubber gaskets and fittings that are suitable for many fluid flow applications typically are avoided in high purity gas flow systems.

[0009] To minimize diffusion of gas into and through plastic components and to minimize moisture absorption, many valves for high purity gas flow systems are provided with valve seats and/or valving members formed from plastics that substantially minimize these problems. For example, prior art diaphragm valves used in high purity gas flow systems may employ a metallic diaphragm and a PCTFE valve seat surrounding the inlet passage to the valve. PCTFE is known to provide very good sealing properties and to present minimal gas diffusion and moisture absorption problems. Although these diaphragm valves have worked fairly well in the past, there is a desire for even greater degrees of purity in the gases being carried. Accordingly, there is a desire to provide valves that are free of plastics, including the heretofore acceptable plastics such as PCTFE.

[0010] The simple removal of plastic components

from prior art valves would eliminate problems associated with gas diffusion and moisture absorption. However, the industrial processes in which these valves are used must positively stop the flow of gases in the closed condition of the valve. Thus, engineers have been faced with a dichotomy. Prior art valves could be formed with at least some plastic components to provide effective sealing, but with the potential for gas diffusion and moisture absorption. Alternatively prior art valves could be formed without plastic components to avoid gas diffusion and moisture absorption, but with the near certainty for less than optimum sealing performance.

[0011] The prior art includes all metal valves that rely upon a significant wiping action between two members to be sealed. This wiping action occurs in some prior art valves as one planar surface is twisted into tight sealing engagement with a second planar surface having an inlet or outlet passage. In other prior art valves, the wiping occurs as a conical member is slid into a cylindrical opening. Wiping actions of this type invariably generate wear debris and cause particles to enter the gas stream. These particles significantly affect the purity of the gas and can adversely affect the manufacturing process being carried out in the presence of the gas.

[0012] The US 5,108,069 discloses a metal diaphragm valve including a diaphragm made of an elastic material and having an upward bulge in the center. The diaphragm is actuated by a vertically shiftable push rod to press the diaphragm against an annular valve seat to close an inlet passage of the valve.

[0013] The quality of the seal achieved by a diaphragm valve depends, in part, on the positioning and alignment of the various components. For example, a valve stem that is not perfectly aligned to the center of the diaphragm can lead to uneven deflection of the diaphragm and hence imperfect sealing. Additionally, improper alignment of the valve stem can lead to a faster wear of the diaphragm by creating more stress on one portion of the diaphragm than on another. Components of a diaphragm valve can be manufactured to a very high tolerance for assuring perfect alignment. However, the quality control for achieving near perfect alignment increases manufacturing costs significantly.

[0014] The quality of the seal also depends upon the pressure of the gas flowing through the valve and the force exerted by the valve stem on the diaphragm. A higher gas pressure differential across the closed diaphragm generally requires higher forces to be exerted by the prior art valve stem for achieving proper sealing. The force exerted by a manually rotatable valve stem can be varied as needed to achieve proper sealing. Thus, some manually operable diaphragm valves achieve a high quality seal in valves with a gas pressure differential across the closed diaphragm of about 3000 p.s.i. It is more difficult to achieve a good seal in an automatically actuated diaphragm valve, because forces applied to the valve stem generally are not adjustable. Therefore, automatically actuated diaphragm valves seldom have been used above a 500 p.s.i. gas pressure differential across the closed diaphragm. Actuators could be used for routinely exerting a much higher pressure on the diaphragm. However, such a high pressure on each actuation creates the potential for damaging the diaphragm or the sealing surface against which the prior art diaphragm is urged.

[0015] In view of the above, it is an object of the subject invention to provide a diaphragm valve that achieves a more effective sealing with a high degree of precision and is less expensive.

[0016] This object is achieved by a diaphragm valve having the features disclosed in claim 1. Preferred embodiments are defined in the dependent subclaims.

DISCLOSURE OF INVENTION

[0017] The diaphragm valve has only metallic components exposed to gases flowing therethrough. The diaphragm valve of the subject invention includes a valve housing having an open-sided valve chamber. Inlet and outlet passages extend through the valve housing and into the valve chamber. Portions of the metallic valve housing surrounding the entry of the inlet passage into the valve chamber define a toroidal sealing bead that is concentric with the inlet passage and that may be unitary with the valve housing.

[0018] The diaphragm valve of the subject invention further includes a metallic diaphragm defining a wall of the valve chamber. The metallic diaphragm is juxtaposed to the toroidal sealing bead that surrounds the entry of the inlet passage to the valve chamber. Central portions of the metallic diaphragm are of dished configuration. Dished portions of the diaphragm project away from the inlet passage to define the open condition of the valve. The dished shape of the diaphragm requires a longer stroke for closure of the valve, and hence effectively defines a larger valve chamber which can accommodate a greater gas flow. The dished shape also provides resiliency which permits the valve to be repeatedly opened as explained further herein without being pulled open by an actuator.

[0019] The diaphragm valve of the subject invention further includes an actuating means for engaging the convex side of the metallic diaphragm opposite the valve chamber. The actuating means comprises a valve stem movable axially toward and away from the metallic diaphragm. The valve stem may be operatively engaged with an automatic actuator for selectively urging the valve stem toward and away from the metallic diaphragm with a predetermined force. The actuator may be of known construction and may be operable for linearly moving the valve stem without a corresponding rotational movement thereof.

[0020] The actuating means further includes an actuating button disposed between the valve stem and the diaphragm. The actuating button is movably disposed adjacent an end of the valve stem and hence can float

radially relative to the valve stem and the diaphragm. The end of the actuating button facing away from the valve stem is arcuately convex, and preferably is spherically generated. With this assembly of the actuating means, the actuator will drive the valve stem and the actuating button into engagement with the convex side of the metallic diaphragm for deflecting the metallic diaphragm toward the inlet passage and into tight sealing engagement with the toroidal sealing bead at the entry of the inlet passage into the valve chamber. In particular, actuation of the valve stem causes the metallic diaphragm to achieve a circular line of sealing contact with the toroidal sealing bead. The circular line of contact enabled by the toroidal sealing bead achieves a high quality seal despite the absence of a plastic or rubber material on either of the interengaged surfaces defining the seal. The actuating means will cause the surface of the diaphragm facing away from the inlet passage to deflect from an initially convex shape into a slightly concave shape. Thus, portions of the diaphragm will deflect across a plane defined by the toroidal sealing bead around the inlet to the valve chamber. This deflection into a concave shape will cause the actuating button to float radially relative to the valve stem into a position substantially centered on the axis about which the toroidal sealing bead is generated. Thus, with each actuation of the diaphragm valve, the actuating button will assume a very accurate coaxial alignment with the axis of the toroidal sealing bead but without the high cost that normally would be associated with efforts to achieve a high degree of precision. In this embodiment, the valve stem is not rotating, and hence the actuating button performs no function in isolating the diaphragm from rotational movement.

[0021] The diaphragm may be formed from a plurality of metal layers in stacked abutting relationship to one another. In particular, the diaphragm may include outer metallic layers formed from a hard metallic material that is not reactive to gases flowing through the valve. The hard metallic outer layers of the diaphragm may be sandwiched around at least one inner layer of a softer, more malleable metallic material. However, the hard metallic outer layers are not bonded to the softer inner layers, thereby permitting small amounts of at least localized sliding movement of the hard layers relative to the soft layers. The hard metallic outer layers prevent the creation of wear debris after even a large number of valve actuations. Additionally, the hard metallic outer layers provide desirable resiliency for the diaphragm and ensure specified performance over a long life. The softer more malleable metal material between the outer layers permits a controlled micromovement and deformation of the diaphragm for achieving a high quality seal between the diaphragm and the toroidal sealing bead. This controlled micromovement and deformation enables the diaphragm to deform into any minor surface discontinuities that may exist in either the diaphragm or the toroidal sealing bead. The outer layers of the diaphragm may be formed from a metal alloy having a hardness HRC greater than 40. Inner portions of the diaphragm may be formed from copper or silver plated copper. The silver plating facilitate the micromovement between adjacent layers of the diaphragm.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

FIG. 1 is a cross-sectional view of a valve in accordance with the subject invention.

FIG. 2 is an enlarged cross-section showing the valve in the open condition.

FIG. 3 is a cross-section similar to FIG. 2, but showing the valve in the closed condition.

FIG. 4 is a top plan view of the diaphragm.

FIG. 5 is an exploded cross-sectional view of the diaphragm shown in FIG. 1.

MODES FOR CARRYING OUT THE INVENTION

[0023] A valve in accordance with the subject invention is identified generally by the numeral 10 in FIG. 1. The valve 10 includes a metallic valve housing 12 unitarily molded and/or machined from a metallic material, and preferably from stainless steel. The valve housing 12 includes an inlet passage identified generally by the numeral 14 in FIG. 1. The inlet passage 14 includes orthogonally aligned upstream and downstream segments 16 and 18 respectively. The downstream segment 18 of the inlet passage 14 terminates at a valve chamber 20. The inlet passage 14 is operative to deliver a specified gas at pressures of up to 3000 p.s.i. into the valve chamber.

[0024] The valve chamber 20 includes a short cylindrical side wall 22 concentric with the downstream segment 18 of the inlet passage 14. The valve chamber 20 is further defined by a generally annular base wall 24 extending inwardly from the side wall 22 toward the downstream segment 18 of the inlet passage 14. The base wall 24 is orthogonal to the axis of the downstream segment 18 of the inlet passage 14 and orthogonal to the side wall 22. An annular diaphragm seat 26 extends radially outwardly from portions of the side wall 22 remote from the base wall 24. The diaphragm seat 26 is concentric with the axis of the downstream segment 18 of the inlet passage 14 and is substantially parallel to the base wall 24 of the valve chamber 20.

[0025] A toroidal sealing bead 28 forms the interface between the downstream segment 18 of the inlet passage 14 and the base wall 24 of the valve chamber 20. The toroidal sealing bead 28 effectively defines a semicircle rotated about the axis of the downstream segment 18 of the inlet passage 14. Inner circumferential portions of the toroidal sealing bead 28 extend continuously and substantially tangentially from the cylindrical side walls defining the downstream segment 18 of the

inlet passage 14. The toroidal sealing bead 28 defines a height measured from the base wall 24 substantially equal to the height of the side wall 22. Thus, a plane orthogonal to the axis of the downstream segment 18 of the inlet passage 14 and tangential to the toroidal sealing bead 28 will be coplanar with the diaphragm seat 26.

[0026] An outlet passage 30 is formed in the valve housing 12 and extending from the valve chamber 20 to an external location on the valve housing 12. More particularly, the outlet passage 30 includes an upstream segment 32 extending substantially parallel to the downstream segment 18 of the inlet passage 14. The upstream segment 32 of the outlet passage 30 intersects the bottom wall 24 of the valve chamber 20 at a location intermediate the toroidal sealing bead 28 and the side wall 22 of the valve chamber 20. The outlet passage 30 further includes a downstream segment 34 extending substantially colinearly with the upstream segment 16 of the inlet passage 14.

[0027] As shown most clearly in FIG. 1, the extreme upstream end of the inlet passage 16 and the extreme downstream end of the outlet passage 30 define nipples to which other pipes or fittings may be connected.

[0028] The valve housing 12 is further defined by a short cylindrical diaphragm positioning wall 36 extending concentrically about the axis of the downstream segment 18 of the inlet passage 16. The diaphragm positioning wall 36 defines a diameter substantially equal to the diameter of a diaphragm to be used with the valve 10. The height of the diaphragm positioning wall 36 exceeds the thickness of the diaphragm to be used in the valve 10, as explained further herein.

[0029] Outer portions of the valve housing 12 surrounding the valve chamber 20 are formed with an array of external threads for threadedly receiving a bonnet nut as explained further herein.

[0030] The valve 10 further includes a metal diaphragm 40 as shown in FIGS. 4 and 5. The diaphragm 40 includes a substantially planar annular peripheral portion 42 and a resiliently dished intermediate portion 44. The planar annular peripheral portion 42 defines a diameter slightly less than the diameter defined by the diaphragm positioning wall 36 of the valve housing 12, and a thickness less than the height of the cylindrical diaphragm positioning wall 36. Additionally, the planar annular peripheral portion 42 defines an inside diameter adjacent the dished portion 44 of the diaphragm 40 which is approximately equal to the diameter defined by the side wall 22 of the valve chamber 20. Thus, the planar peripheral portion 42 of the diaphragm 40 is positioned on the cylindrical diaphragm seat 26 and within the diaphragm positioning wall 36.

[0031] The dished intermediate portion 44 has a inner face 46 that is initially concave and an outer face 48 that is initially convex. The diaphragm 40 is oriented such that the initially concave inner face 46 of the dished portion 44 faces the valve chamber 20. Conversely, the initially convex outer face 48 faces away from the valve housing 12.

[0032] As shown most clearly in FIG. 5, the diaphragm is of stacked configuration, and is formed from diaphragm layers 51-55. The layers 51, 53 and 55 are formed from a relatively hard, inert and resilient material, while the layers 52 and 54 are formed from a relatively softer material. In a preferred embodiment, the layers 51, 53 and 55 are formed from a metallic alloy exhibiting a hardness HRC of 45 to 60. The diaphragm layers 51, 53 and 55 preferably are formed from a cobalt chromiumnickel alloy, such as an alloy having 39%-41% cobalt; 19-21% chromium, 14%-16% nickel, 1.5%-2.5% manganese, 0.15 max percent carbon, 0.10 max percent beryllium and iron-balance (about 16%). An example of such an alloy is ELGILOY® which is sold by ELGILOY LP. The layers 52 and 54 of the diaphragm 50 are formed from a softer more malleable metallic material, such as copper, and preferably copper plated with silver. The respective layers 51-55 of the stacked diaphragm 40 are not bonded together. Hence, deformation and associated micromovement of adjacent layers is possible for accommodating surface irregularities that may exist in the toroidal sealing bead 28.

[0033] Returning to FIG. 1, the valve 10 further includes a diaphragm bushing 56 having a large diameter first end 58 and a small diameter second end 60 and a bearing shoulder 62 therebetween. The first end 58 of the bushing 56 defines an outside diameter substantially equal to the diameter of the diaphragm 40. Thus, the large diameter end 58 can be closely received within the diaphragm positioning wall 36. The first end 58 of the bushing 56 includes an end face having a generally planar outer peripheral surface 64 dimensioned for engaging the planar outer peripheral portion 42 of the diaphragm 40. The end face of the bushing 56 further includes a concave central portion 66 which is dished slightly more than the dished portion 44 of the diaphragm 40 to avoid interference therewith. The bushing 56 includes a non-threaded central aperture 68 extending entirely therethrough.

[0034] A stainless steel diaphragm actuator button 70 is slidably received for axial movement in the non-threaded central aperture 68. The diaphragm actuator button 70 is cross-sectionally smaller than the cross-section of the central aperture 68 through the bushing 56. Thus, the diaphragm actuator button 70 is capable of transverse movement or float within the central aperture 68 of the bushing 56. The diaphragm actuator button 70 includes a spherically generated convex actuating face 72 positioned adjacent the convex face 48 of the dished portion 44 on the diaphragm 40. The diaphragm actuator button 70 also includes an opposed end 73 aligned substantially orthogonally to the axis of the central aperture 68 in the bushing 56. The end 73 is planar and smoothly finished.

[0035] The valve 10 further includes a non-threaded valve stem 74 slidably engaged with the central aperture 68 in the bushing 56. The valve stem 74 includes op-

posed inner and outer ends 75 and 76. The inner end 75 of the valve stem 74 is smoothly finished and aligned substantially orthogonally to the axis of the central aperture 68. Thus, the smooth planar end 73 of the diaphragm actuator button 70 will be engaged by the smooth planar inner end 75 of the valve stem 74. The outer end 76 of the valve stem 74 is engaged with an actuator 78 which functions to selectively and non-rotatably urge the valve stem 74 toward or away from the valve chamber 20. Movement of the valve stem 74 toward the valve housing 12 will urge the smooth planar inner end 75 into the smooth planar end 73 of the actuator button 70. These forces will urge the convex actuating face 72 of the diaphragm actuator button 70 into the initially convex outer face 48 of the diaphragm 40, thereby causing a deflection of the diaphragm 40 into the valve chamber 20 as explained further herein. Conversely, threaded movement of the valve stem 74 away from the valve housing 12 will release forces exerted by the diaphragm actuator button 70 on the convex face 48 of the diaphragm 40, thereby enabling resilient return of the diaphragm toward an undeflected position as shown in FIGS. 1 and 2.

[0036] The valve 10 further includes a bonnet nut 82 threadedly engaged to the threads 38 on the valve housing 12. The bonnet nut 82 includes an inwardly extending flange 84 which surrounds the small diameter portions of the bushing 56, and which engages the shoulder 62 between the small and large diameter portions 60 and 58 of the bushing 56. Thus, threaded tightening of the bonnet nut 82 onto the valve housing 12 tightly urges the large diameter end 58 of the bushing 56 into secure gripping engagement with the diaphragm 40 for tightly securing the planar outer peripheral portion 42 of the diaphragm 40 against the diaphragm seat 26.

[0037] As shown in FIGS. 1 and 2, the valve stem 74 is in a position relatively remote from the valve housing 12. In this position, the inherently resilient hard metallic alloy layers 51, 53 and 55 of the diaphragm 40 urge the smooth planar end 73 diaphragm actuator button 70 outwardly against the end 75 of the valve stem 74, such that a space exists between the toroidal sealing bead 28 and the concave face 46 of the diaphragm 40. Thus, the gaseous fluid flow may proceed without substantial impediment through the inlet passage 14 through the valve chamber 20 and out the outlet passage 30.

[0038] The valve 10 may be closed by advancing the valve stem 74 further in the bushing 56 and toward the housing 12 under forces generated by the actuator 78. This movement of the valve stem 74 toward the housing 12 will transmit forces to the diaphragm actuator button 70. The spherically generated convex surface 72 of the diaphragm actuator button 70 will be urged tightly against the initially convex outer surface 48 of the dished portion 44 of the diaphragm 40. These forces will cause the dished portion 44 of the diaphragm 40 to deflect into the orientation shown in FIG. 3. In this configuration, the spherically generated convex surface 72 of the diaphragm actuator button 70 will contact only the central portion of the initially convex outer surface 48 of the diaphragm 40, and will urge the centermost regions of the diaphragm 40 beyond the plane extending tangentially across the toroidal sealing bead 28. Thus, central portions of the outer surface 48 of the sealed diaphragm 40 will be deflected to have a slightly concave shape. The concave shape assumed by the outer surface 48 of the diaphragm 40 will be substantially symmetrical relative to the toroidal sealing bead 28. Conceivably, the diaphragm actuator button 70 initially may not be perfectly aligned with the axis of the toroidal sealing bead 28. However, as the outer surface 48 of the diaphragm 40 deflects into the concave shape shown in FIG. 3, the diaphragm actuator button 70 will float transversely to be centered relative to the concave shape assumed by the outer surface 48 of the diaphragm 40. The floating will be generated by a slight sliding movement of the spherically generated convex surface 72 of the diaphragm actuator button 70 along the concave outer surface 48 of the diaphragm and in response to forces generated by the valve stem 74. The transverse floating will end when the center of the convex surface 72 of the diaphragm actuator button 70 is coincident with the center of the concave portions assumed by the outer surface 48 of the diaphragm 40. This float will center the diaphragm actuator button along the axis about which the toroidal sealing bead 28 is generated. Coaxial positioning of the diaphragm actuator button 70 and the toroidal sealing bead 28 will result in a substantially uniform application of forces to the diaphragm 40 with a high quality seal uniformly around the toroidal sealing bead. Portions of the diaphragm 40 between the diaphragm seat 26 and the center of the diaphragm actuator 70 will exert significant biasing forces against the toroidal sealing bead 28. These forces will effectively define a circular line of contact at the plane of tangency or slightly inwardly therefrom as shown in somewhat exaggerated form in FIG. 3. These biasing forces will contribute to a high quality seal without the presence of non-metallic materials at the sealing interface.

[0039] Subsequent opening and closing of the valve 10 will cause the metal diaphragm 40 to seat at substantially the same position on the toroidal sealing bead 28 with virtually no metal-to-metal sliding movement of the diaphragm 40 against the toroidal sealing bead 28. Additionally, the diaphragm actuator button 70 is unlikely to float out of coaxial alignment with the axis of the toroidal sealing bead during subsequent actuations. Thus, unlike prior art all-metal valves described above, there is no generation of wear debris that could affect the purity of gases being transported. Furthermore, the very hard alloy of the layers 51, 53 and 55 of the diaphragm 40 exhibit good spring characteristic and resiliency, and thus will exert high sealing forces against the toroidal sealing bead 28. The softer layers 52 and 54 undergo micromovement relative to the adjacent hard layers 51, 53 and 55 and enable the adjacent hard layers 51, 53

and 55 to deform slightly into sealing engagement with the toroidal sealing bead 28 despite any microscopic surface irregularities that might exist at the sealing interface. This micromovement between the hard and softer layers is facilitated by the silver plating on the softer layers.

[0040] While the invention has been described with respect to a preferred embodiment, it is apparent that various changes can be made without departing from the scope of the invention as defined by the appended claims. For example, the diaphragm may be formed from fewer or more layers of metal. Additionally, the arrangement of layers of material in the diaphragm may be slightly different from that shown herein. However, the layers of the diaphragm should be arranged to ensure a very hard metallic alloy for engagement with the toroidal sealing bead and a relatively soft layer adjacent to the hard layer. Additionally, the valve housing may take other forms, with different relative positions for the inlet and outlet passages and with other actuating means, including a pneumatic valve actuator rather than the manual handle depicted herein. These and other changes will be apparent to a person skilled in the art after having read the subject disclosure.

Claims

1. A diaphragm valve (10), comprising

   a metallic valve housing (12) with an open-sided valve chamber (20), an inlet passage (14) extending through said valve housing (12) to said valve chamber (20) and an outlet passage (30) extending through said valve housing (12) from said valve chamber (20), said valve housing (12) being formed to include a toroidal sealing bead (28) in said valve chamber (20) and surrounding said inlet passage (14);

   a resiliently deflectable metallic diaphragm (40) secured to said valve housing (12) to substantially enclose said open-sided valve chamber (20), said diaphragm (40), in an undeflected condition, including a dished central portion (44) with a concavely arcuate surface (46) in juxtaposed relationship to said toroidal sealing bead (28) and being spaced from said toroidal sealing bead (28) in said undeflected condition for permitting fluid flow into said inlet passage (14), through said valve chamber (20) and out of said outlet passage (30), said diaphragm (40), in an undeflected condition further including a convexly arcuate surface (48) facing away from said chamber (20);

   and a valve stem (74) disposed externally of said valve chamber (20) and being selectively movable toward and away from said diaphragm (40); said valve (10) being **characterized by**:

   a diaphragm actuator button (70) disposed between said valve stem (74) and said diaphragm (40), said diaphragm actuator button (70) being slidably movable transversely relative to said valve stern (74) and having a convex face (72) engaged with said initially convex face (48) of said central portion (44) of said diaphragm (40) for selectively deflecting said metallic diaphragm (40) into tight sealing engagement with said toroidal sealing bead (28) in response to movement of said valve stem (74) toward said valve housing (12) for interrupting fluid flow into and out of said valve chamber (20), whereby said slidable movement of said diaphragm actuator button (70) transverse to said axis of said valve stem (74) enables the diaphragm actuator button (70) to float into a position substantially centered on the axis about which the sealing bead is generated for achieving substantially uniform application of forces by the diaphragm (40) on the toroidal sealing bead (28).

2. The diaphragm valve of claim 1, wherein the convex face (72) of the diaphragm actuator button (70) is spherically generated.

3. The diaphragm valve of claim 1, wherein said initially convex central portion (48) of said diaphragm (40) is disposed relative to said toroidal sealing bead (28) such that said portions of said diaphragm (40) engaging said actuator button assume a concave configuration when said diaphragm (40) is sealingly engaged with said toroidal sealing bead (28).

4. The diaphragm valve of claim 1, further comprising actuator means (78) for selectively moving said valve stem (74) toward and away from said valve housing (12).

5. The diaphragm valve of claim 1, wherein the actuator means (78) non-rotatably moves said valve stem (74).

6. The diaphragm valve of claim 5, wherein the actuator means (78) is an automatic pneumatic actuator (78).

7. The diaphragm valve of claim 1, wherein the metallic diaphragm (40) comprises at least three layers (51-55) of metallic material disposed in adjacent non-bonded relationship to one another, said layers comprising a sealing layer (51) disposed for engagement with the toroidal sealing bead (28), an actuating layer (55) disposed for engagement with

said diaphragm actuator button (70) and at least one inner layer (52-54) therebetween, said at least one inner layer (52-54) comprising at least one layer (52, 54) formed from a metal material softer than said sealing layer (46) and said actuating layer (55) and permitting micromovement and minor deformations of said layers (51-55) for sealing surface discontinuities in either one of said diaphragm (40) and said toroidal sealing bead (28).

8. The diaphragm valve of claim 7, wherein the outer layers (51, 55) of said diaphragm (40) are formed from a cobalt chromium nickel alloy.

9. The diaphragm of claim 7, wherein said at least one soft inner layer (52, 54) comprises a plurality of soft inner layers (52, 54), and wherein said diaphragm (40) includes at least one hard inner layer (53) disposed between the soft inner layers (52, 54), the hard inner layer (53) and the outer layers (51, 55) of said diaphragm (40) are formed from a hard cobalt chromium nickel alloy, and wherein said soft inner layers (52, 54) of said diaphragm (40) adjacent said cobalt chromium nickel alloy layers are formed from copper plated with silver.

Patentansprüche

1. Membranventil (10), aufweisend:

ein metallisches Ventilgehäuse (12) mit einer seitenoffenen Ventilkammer (20), einem Einlasskanal (14), der sich durch das Ventilgehäuse (12) zur Ventilkammer (20) erstreckt, und einen Auslasskanal (30), der sich durch das Ventilgehäuse (12) von der Ventilkammer (20) erstreckt, wobei das Ventilgehäuse (12) derart gebildet ist, dass es einen torischen bzw. ringförmigen Dichtungswulst (28) in der Ventilkammer (20) einschließt und den Einlasskanal (14) umgibt;
eine federnd ablenkbare metallische Membran (40), die an dem Ventilgehäuse (12) sicher befestigt ist, um die seitenoffene Ventilkammer (20) im wesentlichen einzuschließen, wobei die Membran (40) im nicht abgelenkten Zustand einen einwärts gekrümmten Mittelabschnitt (44) einschließt mit einer konkav gebogenen Oberfläche (46) in nebeneinanderliegender Beziehung zum torischen Dichtungswulst (28) und im nicht abgelenkten Zustand von dem torischen Dichtungswulst (28) beabstandet, um einen Flüssigkeitsfluss in den Einlasskanal (14), durch die Ventilkammer (20) und aus dem Auslasskanal (30) zu ermöglichen, wobei die Membran (40) im nicht abgelenkten Zustand des Weiteren einen konvex gebogene Oberfläche (48) einschließt, die von der Kammer (20) wegweist;
und einen Ventilschaft (74), der außerhalb der Ventilkammer (20) angeordnet ist und selektiv zu der Membran (40) hin und von dieser weg bewegt werden kann; wobei das Ventil (10) **gekennzeichnet ist durch**:

einen Membranbetätigungsknopf (70), der zwischen dem Ventilschaft (74) und der Membran (40) angeordnet ist, wobei der Membranbetätigungsknopf (70) quer zu dem Ventilschaft (74) gleitbar beweglich ist und eine konvexe Oberfläche (72) aufweist, die mit der anfänglich konvexen Oberfläche (48) des Mittelabschnitts (44) der Membran (40) im Eingriff steht, um die metallische Membran (40) selektiv in einen engen Dichtungseingriff mit dem torischen Dichtungswulst (28) in Abhängigkeit der Bewegung des Ventilschafts (74) zum Ventilgehäuse (12) hin abzulenken, um den Flüssigkeitsfluss in die und aus der Ventilkammer (20) zu unterbrechen, wobei die Gleitbewegung des Membranbetätigungsknopfes (70) quer zur Achse des Ventilschafts (74) es ermöglicht, dass der Membranbetätigungsknopf (70) in eine Position im Wesentlichen zentriert auf der Achse, um die der Dichtungswulst gebildet ist, getrieben wird, um ein im wesentlichen gleichmäßiges Anlegen von Kräften an den torischen Dichtungswulst (28) **durch** die Membran (40) zu erreichen.

2. Membranventil nach Anspruch 1, wobei die konvexe Oberfläche (72) des Membranbetätigungsknopfes (70) kugelförmig gebildet ist.

3. Membranventil nach Anspruch 1, wobei der anfänglich konvexe Mittelabschnitt (48) der Membran (40) relativ zu dem torischen Dichtungswulst (28) derart angeordnet ist, dass die Abschnitte der Membran (40), die mit dem Betätigungsknopf im Eingriff stehen, eine konkave Konfiguration annehmen, wenn die Membran (40) dichtend mit dem torischen Dichtungswulst (28) im Eingriff steht.

4. Membranventil nach Anspruch 1, des Weiteren aufweisend eine Betätigungseinrichtung (78) zum selektiven Bewegen des Ventilschafts (74) zum Ventilgehäuse (12) hin und von diesem weg.

5. Membranventil nach Anspruch 1, wobei die Betätigungseinrichtung (78) den Ventilschaft (74) drehfest bewegt.

6. Membranventil nach Anspruch 5, wobei die Betäti-

gungseinrichtung (78) ein automatisches pneumatisches Betätigungselement (78) ist.

7. Membranventil nach Anspruch 1, wobei die metallische Membran (40) mindestens drei Schichten (51-55) eines metallischen Materials aufweist, das in nebeneinanderliegender, nicht gebundener Beziehung zueinander angeordnet ist, wobei die Schichten eine Dichtungsschicht (51), die zum Eingriff mit der torischen Dichtungswulst (28) angeordnet ist, eine Betätigungsschicht (55), die zum Eingriff mit dem Membranbetätigungsknopf (70) angeordnet ist, und mindestens eine Innenschicht (52-54) dazwischen aufweisen, wobei die mindestens eine Innenschicht (52-54) mindestens eine Schicht (52, 54) aufweist, die aus einem Metallmaterial gebildet ist, das weicher als die Dichtungsschicht (46) und die Betätigungsschicht (55) ist und eine Mikrobewegung sowie kleinere Deformationen der Schichten (51-55) ermöglicht, um Unstetigkeiten der Oberfläche entweder in der Membran (40) oder in der torischen Dichtungswulst (28) zu dichten.

8. Membranventil nach Anspruch 7, wobei die Außenschichten (51, 55) der Membran (40) aus einer Kobalt-Chrom-Nickellegierung gebildet sind.

9. Membran nach Anspruch 7, wobei die mindestens eine weiche Innenschicht (52, 54) eine Vielzahl von weichen Innenschichten (52, 54) aufweist und wobei die Membran (40) mindestens eine harte Innenschicht (53) aufweist, die zwischen den weichen Innenschichten (52, 54) angeordnet ist, die harte Innenschicht (53) und die Außenschichten (51, 55) der Membran (40) aus einer harten Kobalt-Chrom-Nickellegierung gebildet sind und wobei die weichen Innenschichten (52, 54) der Membran (40) neben den Kobalt-Chrom-Nickellegierungsschichten aus mit Silber plattiertem Kupfer gebildet sind.

Revendications

1. Vanne à membrane (10), comprenant

   un boîtier métallique (12) de vanne pourvu d'une chambre de vanne à côté ouvert (20), un conduit (14) d'entrée s'étendant à travers ledit boîtier (12) de vanne vers ladite chambre de vanne (20) et un conduit (30) de sortie s'étendant à travers ledit boîtier (12) de vanne depuis ladite chambre de vanne (20), ledit boîtier (12) de vanne étant formé pour comprendre un bourrelet d'étanchéité toroïdal (28) dans ladite chambre de vanne (20) et entourant ledit conduit (14) d'entrée ;

   une membrane métallique (40) pouvant fléchir de manière élastique fixée audit boîtier (12) de vanne pour confiner sensiblement ladite chambre de vanne à côté ouvert (20), ladite membrane (40), dans un état non fléchi, comprenant une partie centrale bombée (44) pourvue d'une surface arquée de manière concave (46) dans une disposition juxtaposée par rapport audit bourrelet d'étanchéité toroïdal (28) et étant espacée dudit bourrelet d'étanchéité toroïdal (28) dans ledit état non fléchi pour permettre un écoulement de fluide dans ledit conduit (14) d'entrée, à travers ladite chambre de vanne (20) et hors dudit conduit (30) de sortie, ladite membrane (40), dans un état non fléchi, comprenant en outre une surface arquée de manière convexe (48) tournée à l'écart de ladite chambre (20) ;

   et une tige (74) de vanne disposée à l'extérieur de ladite chambre de vanne (20) et étant mobile sélectivement en s'approchant et en s'écartant de ladite membrane (40) ;

   ladite vanne (10) étant **caractérisée par** :

   un bouton actionneur (70) de membrane disposé entre ladite tige (74) de vanne et ladite membrane (40), ledit bouton actionneur (70) de membrane étant mobile de manière coulissante transversalement à ladite tige (74) de vanne et comportant une face convexe (72) engagée avec ladite face initialement convexe (48) de ladite partie centrale (44) de ladite membrane (40) pour faire fléchir sélectivement ladite membrane métallique (40) en engagement d'étanchéité serré avec ledit bourrelet d'étanchéité toroïdal (28) en réponse à un déplacement de ladite tige (74) de vanne vers ledit boîtier (12) de vanne dans le but d'interrompre un écoulement de fluide dans et hors de ladite chambre de vanne (20), ce par quoi ledit déplacement coulissant dudit bouton actionneur (70) de membrane transversal audit axe de ladite tige (74) de vanne permet un flottement du bouton actionneur (70) de membrane dans une position sensiblement centrée sur l'axe autour duquel est réalisé le bourrelet d'étanchéité pour obtenir une application sensiblement uniforme de forces par la membrane (40) sur le bourrelet d'étanchéité toroïdal (28).

2. Vanne à membrane selon la revendication 1, dans laquelle la face convexe (72) du bouton actionneur (70) de membrane est réalisée sphérique.

3. Vanne à membrane selon la revendication 1, dans

laquelle ladite partie centrale initialement convexe (48) de ladite membrane (40) est disposée par rapport audit bourrelet d'étanchéité toroïdal (28) de façon que lesdites parties de ladite membrane (40) engageant ledit bouton actionneur prennent une configuration concave lorsque ladite membrane (40) est engagée de manière étanche par ledit bourrelet d'étanchéité toroidal (28).

4. Vanne à membrane selon la revendication 1, comprenant en outre un moyen actionneur (78) destiné à déplacer sélectivement ladite tige (74) de vanne en l'approchant et en l'écartant dudit boîtier (12) de vanne.

5. Vanne à membrane selon la revendication 1, dans laquelle le moyen actionneur (78) déplace ladite tige (74) de vanne sans rotation.

6. Vanne à membrane selon la revendication 5, dans laquelle le moyen actionneur (78) est un actionneur pneumatique automatique (78).

7. Vanne à membrane selon la revendication 1, dans laquelle la membrane métallique (40) comprend au moins trois couches (51 à 55) de matière métallique disposées dans une disposition adjacente non collées les unes aux autres, lesdites couches comprenant une couche (51) d'étanchéité disposée pour engagement avec ledit bourrelet d'étanchéité toroïdal (28), une couche (55) d'activation disposée pour engagement avec ledit bouton actionneur (70) de membrane, et au moins une couche intérieure (52 à 54) disposée entre elles, ladite au moins une couche intérieure (52 à 54) comprenant au moins une couche (52, 54) formée de matière métallique plus tendre que celle de ladite couche (46) d'étanchéité et de ladite couche (55) d'activation, et permettant un microdéplacement et des déformations mineures desdites couches (51 à 55) dans le but de rendre étanches des discontinuités de surface dans l'un ou l'autre de ladite membrane (40) et dudit bourrelet d'étanchéité toroïdal (28).

8. Vanne à membrane selon la revendication 7, dans laquelle les couches extérieures (51, 55) de ladite membrane (40) sont formées d'un alliage de nickel chrome cobalt.

9. Membrane selon la revendication 7, dans laquelle ladite au moins une couche intérieure tendre (52, 54) comprend une pluralité de couches intérieures tendres (52, 54), et dans laquelle ladite membrane (40) comprend au moins une couche intérieure dure (53) disposée entre les couches intérieures tendres (52, 54), la couche intérieure dure (53) et les couches extérieures (51, 55) de ladite membrane (40) sont formées d'un alliage de nickel chrome cobalt dur, et dans laquelle lesdites couches intérieures tendres (52, 54) de ladite membrane (40), adjacentes auxdites couches d'alliage de nickel chrome cobalt, sont formées de cuivre plaqué d'argent.

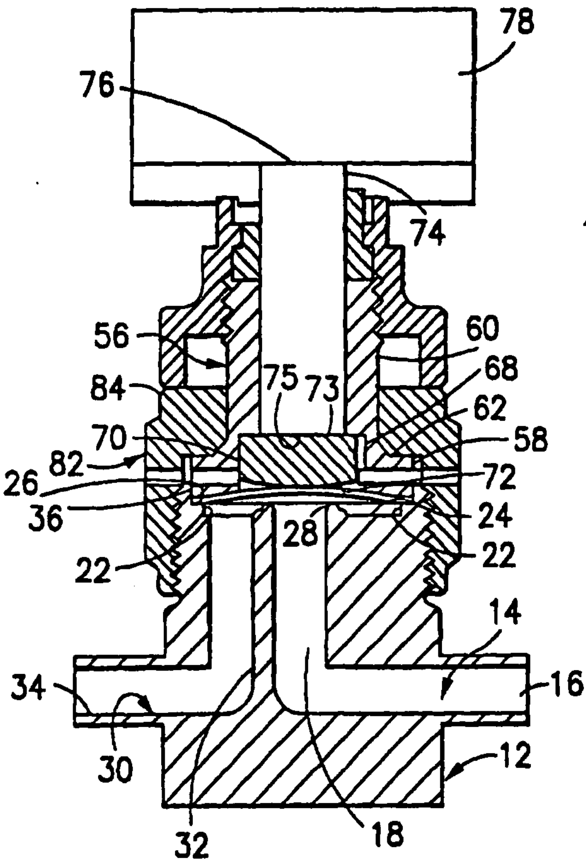

FIG.1

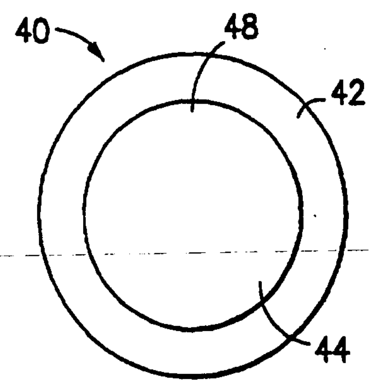

FIG.4

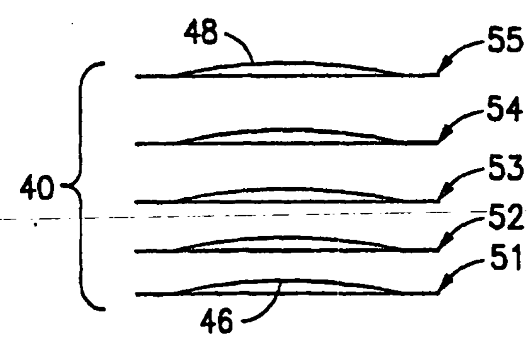

FIG.5

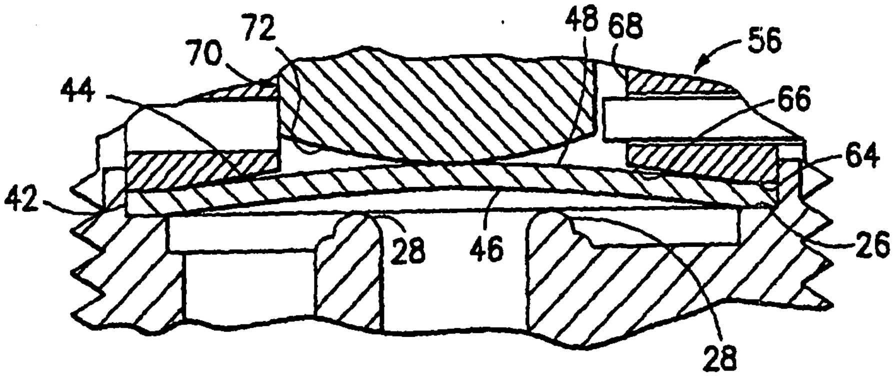

FIG.2

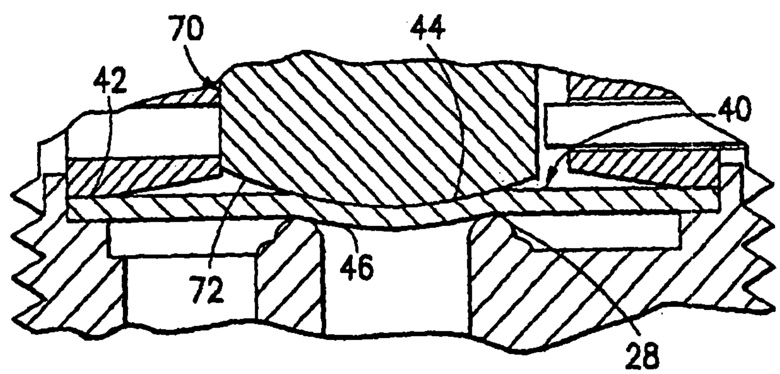

FIG.3